Measurement of airway lumen in video bronchoscopy

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Keywords
Videobronchoscopy, airway dimension, stenosis measurement, tracheal malacia.

Introduction

The aim of the study is to work up a new method for objective and quantitative assessment of the tracheal lumen using computer image analysis and stereology methods. The malacia disorders (decreasing airway lumen on exhaling phase of breathing) may cause chronic cough, recurrent respiratory tract infections, extended postinfectious cough and in severe cases the neccesity to perform tracheostomy (opening through the neck to the trachea). Because of its dynamic nature tracheomalacia can be diagnosed unless patient is breathing spontaneously, which is possible during fiberobronchoskopy. Assessment of airway lumen is based on the visual evaluation of the trachea images from videobronchoscopy examination which strongly depends on the experience and intuition of clinicians. Furthermore this visual estimation unable precise assessment for detection of subtle changes in the tracheal lumen shape. Therefore reliable and quantitative assessment of airway shape and dimensions based on the images from the video bronchoscopy examination may deliver new important diagnostic information which could support therapy process.

Materials and Methods

As research material used for preliminary study were images from video bronchoscopy, obtained on the way of routine examination performed in the Children's University Hospital in Cracow.

Bronchoscopy is diagnostic procedure used to examine the larynx, trachea and bronchi due to reveal causes of some symptoms like chronic cough, recurrent respiratory illness, respiratory tract infections and others. Examination is performed by using flexible video bronchoscope (FVB). This instrument allows to study the interior of airways by insertion into the lungs flexible viewing tube. Bronchoscope is imaging bundle with an eyepiece on one end and distal lens on the other to carry the image of examined area, illumination system, articulation cables, and optional, specialized tools for retrieving samples from inspected area. Throughout the examination of the respiratory tracks the tube is gently inserted through nose down throat, larynx (between the vocal cords) and trachea till the tip of the tube reach bronchial tree. Due to adjust to the natural curves of airways, tube is manipulated by clinicians proceeding the examination. The distal bending end has ability to move in range 180° up and 130° down. Distal lens allow to observe the area in 120° field of view, and in depth of field was from 3 mm to 50 mm. Image from the

inspected areas is directly transmitted in to the workstation and presented in the real-time on the monitor. A course of procedure is recorded mpg format file, where the resolution of the frame is 720x560 pixels.

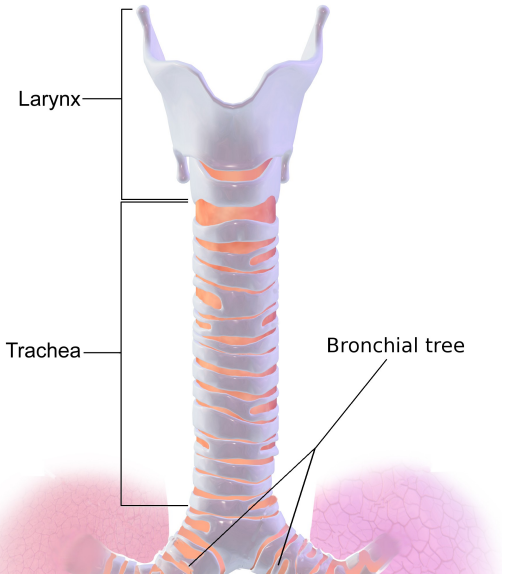

Figure 1: Structure of the trachea with the larynx and the bronchial tree.

Masters et. Al (2005) proposed quantitative assessment of the airway lumen using image processing techniques. They proposed to process chosen for quantitative assessment frames by using technique called “colour histogram mode technique”. This methods involves the use of standard image processing tool for adjusting image colour balance, which allow to increase the contrast between the area of airway lumen and the rest of the image. Detection of the region for further quantitative analysis were performed semi-automatic, using another standard tool in computer graphics software, so called “The Wand”. Quantitative analysis was limited to area of detected airway lumen. Proposed method beside the quantitative, numerous result of the assessment haven’t proposed any new approach for methodology of the image acquisition or method of measurement. Although image processing methods were used, measurement process is still subjective and strongly depend on the doctors.

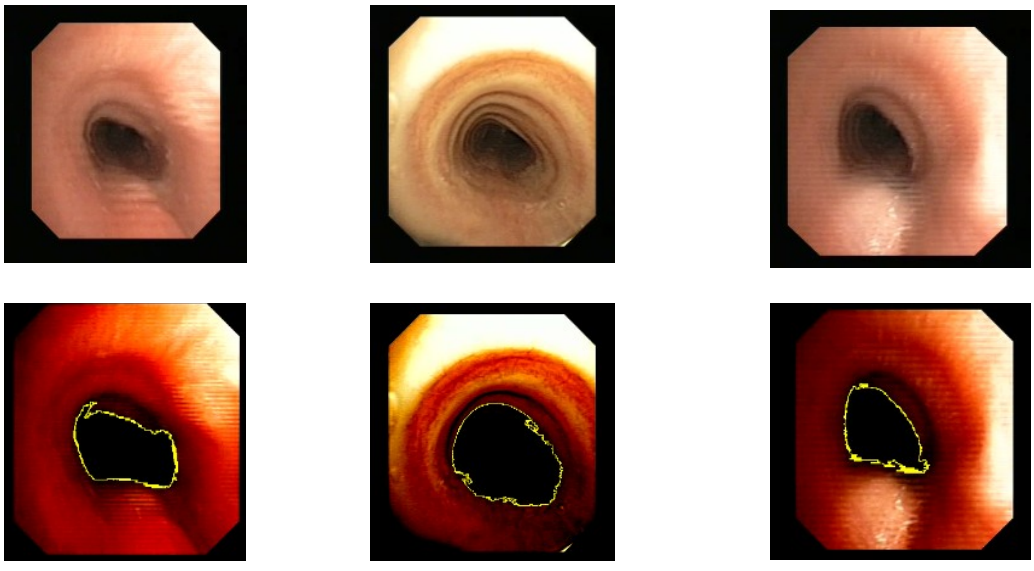

Figure. 2. Example results of the airway lumen detection

Williamson et al. (2009) in comprehensive review of current and emerging techniques for quantifying airway dimensions, presented application of CT imaging techniques, MRI, video bronchoscopy, confocal fluorescence endomicroscopy, optical coherence tomography. All this imaging techniques give some possibilities to measure the airway lumen, but the availability of the equipment is very limited, or its application is only in research area, not for routine diagnostic examination. Williamson enrich method worked out by Masters et al. (2009), by additional image processing procedures, due to correction image distortion. Because in the video bronchoscopes “wide-angle” lens are used, distal and radial distortion is observed on the obtained images. Due to this distortion all measurement are unreliable. Best quality images were obtained by CT method, but it cannot be used for routine diagnosis purpose, because of the X-ray radiation and cost of the single examination.

Our research concentrate on working out complex method of image acquisition, image processing, measurement, and result interpretation, dedicated for video bronchoscopy method which can be implemented in diagnostic procedure without significant costs. Our main goal is to extract all possible information that are written in the captured images to increase the amount of information for diagnosis purpose.

First problem of the analysis is that airway lumen on the bronchoscope images is presented from different angles. Variety orientation of the object in relation to the camera results in different analysed section, hence different results of the measurements. We proposed simple in application and possible to realization in clinical routine, method of leading the insertion tube inside the trachea. During the first stage of examination clinicians manipulates the tip of the bronchoscope, and it is diagnostically required. But next stage is removing the tube from the patient’s trachea. Acquisition of the images for quantitative analysis could be registered in this stage, but clinicians must positioned the insertion tube tip on the wall of the trachea and doesn’t change its orientation while removing it from the patient.

After image acquisition according to the guidelines the image processing and analysis stage is beginning. In order to ensure the objectivity and repeatability of the measurements results the image processing algorithm must be automatic. Working out procedure for image analysis contains distortion correction to eliminate measurements error caused by distal and radial distortion of the lens, automatic airway lumen detection and area and shape assessment of detected trachea intersection. Assessment of the distance and location of the malacia is also interesting information for clinicians, because the range of the changes may influents the severity of symptoms and effectives of the treatment. Precise location on the malacia region is working out using the information which are on the image, and verified by CT image. Other methods that require additional devices for assessment localization of malacia are being considered (Luo et al., 2011; Williamson et al., 2010).

Results and Discussion

Currently used methods do not give a precise result of measurements of the airway dimensions. No methods are available to measure the length of trachea stenosis. We propose a new method obtaining a video to image analysis. Through the use of bronchoscopy navigation system we can measure the length of tracheal stenosis.

Conclusion

Our new approach can give a more precision information about the tracheal malacia and the length on which stenosis occurs. Currently we are during clinical trails.

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